DRAFT ADVISORY CIRCULAR No. 25.865-1
Fire protection of flight controls, engine mounts, and other flight structure

1. PURPOSE. This advisory circular (AC) sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) related to the protection of flight controls, engine mounts and other flight structure from fires in designated fire zones on transport category airplanes.

   This advisory material applies to zonal fires and to low pressure fires and does not apply to "torching" fires resulting from engine casing burn through.

2. RELATED FAR SECTIONS AND ADVISORY MATERIAL.

   FAR 1, FAR 33.17, AC 20-135

3. BACKGROUND.

a. Section 25.865 "Fire protection of flight controls, engine mounts and other flight structure" was added to Part 25 by amendment 25-23 in 1970, although the same requirement had existed for rotorcraft since the early 1960's. The need for this rule for transport category airplanes was highlighted when control problems were experienced on a jet transport airplane after aluminum control rods located outside of the fire zone became distorted due to heat from an engine fire.

b. The rule was set forth by amendment 25-23 with essentially the same text that was used for transport (Category A) rotorcraft. The specific flight controls that were of concern for rotorcraft were those that were essential for making a controlled landing. For transport airplanes it was recognized that making a landing was not as simple and immediate as it could be for a rotorcraft so the rule was written to apply to "essential" flight controls without further qualification. Since engine mounts and other flight structures could also be affected, the rule was made to apply to those components as well.

c. FAA Flight Standards Service Release No. 453, dated November 9, 1961 (a forerunner of the current Advisory Circular system) stated that a component (structure, control, mechanism or other essential part) must resist flame penetration and remain capable of carrying the loads and satisfactorily performing the function for which they are designed when subjected to a standard test flame of 2000 degrees F for 15 minutes. Service Release No. 453 formed the basis of the current advisory material for transport and utility helicopters (AC 29-2A and AC 27-1) and has also been accepted for transport category airplane certification after the rule was adopted for transports.

d. Advisory circular AC 20-135 "Powerplant installation and propulsion system component fire protection test methods, standards, and criteria" contains acceptable information for compliance with the several fire protection requirements and includes the methods and criteria for conducting fire tests on components to establish that they are fireproof. When developing AC 20-135, it was recognized that to establish the fire integrity of structural elements and flight controls, the expected external loads during the fire event would need to be defined and considerations of fail-safety and redundancy would need to be addressed. Since these considerations would take more time to develop, the AC was published excluding

applicability to § 25.865. The FAA has continued to rely on the criteria of Service Release No. 453 as the basic means of compliance, although the methods of fire testing and flame definition were slightly changed to be consistent with the fire definitions of AC 20-135.

e. The term "fireproof" is defined in AC 20-135 (for components other than firewalls) as the capability of a material or component to withstand as well as steel, a 2000 °F flame (± 150 °F) for 15 minutes minimum while still fulfilling its design purpose. FAR part 1 defines "fireproof" (for components other than firewalls) as the capacity to withstand the heat associated with fire at least as well as steel in dimensions appropriate for the purpose for which they are used. Other definitions have been proposed and used which do not refer to any specific material but require the component to withstand the 2000° F flame (± 150° F) for 15 minutes fire condition. Irrespective of what definition is used for the term "fireproof" for a structural member, the capability to withstand the fire condition is integrally tied to the loads expected to be applied to the structural member during the time of exposure to the fire. Experience has shown that essential flight structures, when constructed of steel, are capable of withstanding the loads likely to be applied during the exposure to the fire condition (2000° F flame (± 150° F) for 15 minutes). The use of materials that are equivalent to steel for structural members has been accepted.

f. For materials not shown to be equivalent to steel it has been necessary to consider the installation as a whole. This has required the consideration of shielding, redundancy and the available heat transfer mechanisms in combination with a set of design flight loads. Advisory Circular 25.571-1C, "Damage Tolerance and Fatigue Evaluation of Structure", provides design loads associated with discrete source damage conditions which would exist until landing. The design loads as described and contained in Section 7 are greater than the flight loads expected during the shorter duration of an in-flight fire, but nevertheless have been considered appropriate for conducting the evaluation of the complete structural installations exposed to the prescribed fire condition (2000° F flame (± 150° F) for 15 minutes).

4. DEFINITIONS:

a. Foreseeable fire condition: A realistic fire condition that is assumed for the purposes of qualitatively determining if a component or part could be affected by a fire in the fire zone.

b. Designated fire zone: A fire zone as defined in § 25.1181.

c. Engine Mount: For purposes of compliance to 25.865, the engine mount is considered to consist of the airframe engine mounting structure and engine-side attachment points and adjacent essential structure.

d. Essential: Necessary for continued safe flight and landing.

e. Fire test condition: The conditions associated with the standard fire test described in Advisory Circular AC 20-135 or ISO 2685.

f. Structural Fireproof rating: A fireproof rating relative to a selected standard steel which takes into account the specific heat capacity, conductivity, and strength variation with temperature.

5. DISCUSSION: This section provides several alternatives for addressing components that could be affected by fire in a fire zone. Note that firewalls used to contain the fire zone are considered to remain intact. Within a fire zone, the "effects of fire" relate to the direct flame impingement on the component or shielding if applicable. In areas adjacent to the fire zone the heat generated by the fire in the fire zone is the primary effect for consideration.

- They can be constructed of materials considered to be "fireproof".
- The design (arrangement and redundancy) can be such that the intended function can still be performed under the heat and other conditions likely to occur when there is a fire in the fire zone.
- The component can be shielded so that it is capable of withstanding the effects of fire.

For each of the assessments in the advisory circular, including the application of fire test conditions, validated analyses may be used to represent the transient temperature conditions and strength.

6. FIREPROOF STRUCTURAL MATERIALS.

a. Structural components. Engine mounts and other essential flight structures constructed of steel are considered capable of withstanding the expected flight loads during exposure to the fire condition (2000 °F flame (± 150 °F) for 15 minutes). For other materials intended to carry loads and resist failure in the fire condition, equivalency to steel may be accomplished by the following analytical or test demonstration designed to take into account the specific heat capacity, conductivity, and strength variation with temperature:

1) Unless other dimensions are agreed upon, consider a specimen of round bar of 4000 series steel (exact material TBD), 1.5 inches outside diameter (OD), 1.0 inches inner diameter (ID), and 30 inches long (i.e. 5 times the burner flame diameter). This is considered the reference bar.

2) The bar should be held in position in such a way that the impact of the mounting on the bar installation is minimal (the ideal would be a bar in free space).

3) Using a standard burner defined in AC 20-135 or ISO 2685, apply the heat to the center of the bar and determine the highest average cross section temperature vs. time during a 15 minute exposure.

4) Conduct the same test with the comparison bar except that the diameters (TBD) of the comparison bar should be adjusted so that the comparison bar and the reference bar have the same ultimate tensile strength.

5) Using material strength vs. temperature data (average properties) for the reference bar material and the comparison bar material, determine the minimum ratio of the comparison material strength to the reference steel strength during the 15 minute time period. This is the structural fireproof rating. Structural materials demonstrating a fireproof rating greater than 1.0 may be considered compliant with the intent of § 25.865 without further substantiation.

The following are the fireproof ratings for materials that have been found acceptable by the Administrator for demonstrating compliance with § 25.865:

(These materials will have to be further specified.)

Material	Fireproof rating
4000 series steel (reference)	TBD
Nickel Alloy 718	TBD
410 Steel	TBD
PH13-8Mo Steel	TBD
15-5 PH Steel	TBD
Titanium 6Al-4V	TBD
Titanium 6Al-2Sn-4Zr-2Mo	TBD
IMI 550	TBD
Greek Ascolloy	TBD

7. NON-FIREPROOF MATERIALS USED IN STRUCTURAL COMPONENTS AND INSTALLATIONS.

When the structural materials cannot be shown to be fireproof by paragraph 6, the following assessments at the component and installation level should be made.

Engine mounts and other essential flight structures should be able to sustain expected flight loads with a positive margin of safety for any foreseeable fire in a fire zone. In the absence of a rational definition of a foreseeable fire event and expected flight loads, each structural element

should be individually subjected (as per paragraph 9b.) to the fire test conditions described in AC 20-135 (2000° F for 15 minutes) while sustaining the following loads:

- limit flight loads without failure for at least five minutes, and
- after 5 minutes and until the end of 15 minutes, the engine may be assumed to be shut down and the structure must be able to support the discrete source damage loads described in AC 25.571-1C.

8. FIRE ASSESSMENT OF ESSENTIAL FLIGHT CONTROLS. Essential flight controls that could be affected by a fire in the fire zone should be able to perform their intended function during any foreseeable fire in an adjacent fire zone.

a. Essential flight control structural components should be subjected to the effects of the prescribed fire test condition in the fire zone while assessing their capability to continue to perform their function. The assessment of mechanical components should include any tendency to warp, seize, jam or fail under anticipated control system loads with the prescribed fire test condition.

b. Essential hydraulic components including lines, actuators, seals and valves should be assessed to assure that the function they are intended to perform can still be accomplished under any foreseeable fire condition in the adjacent fire zone.

9. SHIELDING AND REDUNDANCY AND OTHER CONSIDERATIONS.

a. Shielding: Shielding may be provided to protect a component against the effects of fire. The adequacy of the shielding should be determined under paragraphs 7 and 8 with the defined fire conditions by assessing the results of applying the flame on the most critical location of the shielded component(s) with representative impingement.

b. Redundancy: All components and parts that could be affected by a fire in a fire zone should be fireproof or protected from the effects of fire. However, the fail-safe features of the design may be taken into account if it can be shown that no foreseeable fire condition could cause the loss of function of the alternate load paths or alternate control elements. The use of the standard AC20-135 flame has been found to be an acceptable representation of a foreseeable fire condition for assessment of redundancy. The effect of this flame impinging on a target loadpath should be assessed on the alternate loadpaths.

c. Aeroelastic stability: When, due to the effect of temperature, significant changes in stiffness and damping properties of parts occur, such as with elastomeric or non-fireproof materials, aeroelastic stability should be addressed accounting for those changes. The aeroelastic assessment should include flutter and whirlmodes and consider the most critical properties that could exist in a fire condition. It should be shown that the airplane is free from aeroelastic instability within the aeroelastic stability envelope of 25.629(b)(2).